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PROGRESS REPORT

SUPPORTING RESEARCH AND DEVELOPMENT
ON PROXIMITY FUZES FOR GUIDED MISSILES
AND SIMILAR APPLICATIONS (U)



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REPORT NO. PR-56-78
COVERING
1 July - 30 September 1956

DIAMOND ORDNANCE FUZE LABORATORIES
ORDNANCE CORPS . . . DEPARTMENT OF THE ARMY

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DIAMOND ORDNANCE FUZE LABORATORIES

John A. Ulrich, Lt Col
COMMANDING

W. S. Hinman, Jr.
TECHNICAL DIRECTOR

The Diamond Ordnance Fuze Laboratories is a Class II Ordnance installation under the Command of the Chief of Ordnance.

The mission of the Laboratories is as follows:

1. Conduct research and development in the various physical science and engineering fields directed toward meeting the military characteristics for fuzes and related items.
2. Provide consulting and liaison services as required in connection with the development, production and use of items developed in the Laboratories or of related items.
3. Fabricate models and prototypes of items under development at the laboratories.
4. Perform developmental testing, including destructive testing of prototypes.
5. Collect, evaluate, produce, and maintain ordnance logistical intelligence required of the Ordnance Corps under the Army Intelligence Program.

The Diamond Ordnance Fuze Laboratories was established by the Ordnance Corps, Department of the Army, on 27 September 1953. The nucleus for these Laboratories was the personnel and facilities of the Ordnance Divisions of the National Bureau of Standards. The Diamond Ordnance Fuze Laboratories is now responsible for the fuze programs formerly conducted at that Bureau.

Typical fields of activity at the Diamond Ordnance Fuze Laboratories include electronics, physics, mechanics, chemistry, and applied mathematics. Examples of topics in these activities are radiation and field studies, circuit theory and design, development and engineering of mechanical and electromechanical devices, chemical problems, and special electron tube design. The programs include all phases from basic research to product design.

Title: (U) SUPPORTING RESEARCH AND DEVELOPMENT ON PROXIMITY FUZES FOR GUIDED MISSILES AND SIMILAR APPLICATIONS

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FOREWORD

11 DEC 1956

This report, prepared by the Supporting Research Laboratory, includes those projects concerned with general research and development on systems, assemblies, components, materials, processes and theories for use in guided missile fuzing and similar applications.

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FOR THE COMMANDER:

W. S. HINMAN, JR.
Technical Director

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DIAMOND ORDNANCE FUZE LABORATORIES
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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

B. Zendle

x 7660

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Nuclear Propelled Aircraft Radiation Detection

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: 10 April 1956

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

Detection of nuclear radiation from nuclear powered aircraft and its application to fuzing and/or guidance.

STATUS:

1. Background: New item.
2. Results during Report Period:

a. The intensity of 1 Mev gamma rays from a point source in air at atmospheric pressure is reduced at 100 feet distance to approximately $3\frac{1}{4}\%$ of the intensity at 10 feet. Scintillation detectors can detect gamma ray dose rates as low as 10^{-5} r/hr. If the gamma ray dose rate is just above tolerance for personnel 10 feet from a nuclear reactor, this radiation is detectable at 100 feet. The effects from scattered gamma rays and neutrons have been neglected.

b. A guidance system has been conceived having inherent directivity not depending on a radiation flux gradient. It will consist of an array of scintillation detectors.

PLANNED OBJECTIVES FOR NEXT PERIOD:

1. Ascertain from reliable sources whether this effort is desirable and is not being duplicated.
2. Obtain data from nuclear aircraft propulsion centers regarding nuclear radiation flux escaping from the reactor shielding, radiation components, intensities, and energy and angular distributions.

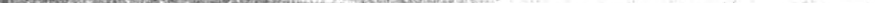
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PROJECT NO.: TA 3-9101

D/A

ENGINEER(S):

P. W. Boesch

x 639

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Noise-Modulated Fuzing System

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: 1951

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

1. To investigate fundamentals of ranging and detection systems which employ noise-modulation or correlation techniques.

2. To utilize these principles in fuze systems for guided missiles.

STATUS:

1. Background: Several complete systems based on noise modulation have been produced. (REF: DOFL TR-24, 67, 73, 210, 216, 251). These systems are free from ambiguities present in periodic systems, and appear to have a high resistance to countermeasures. Applications to both air target and surface target missiles have been studied. Flight tests in aircraft have been performed.

Preliminary work has been done on an S-band system using Cobra principles and a voltage tunable magnetron. (Coral system)

2. Results during Report Period:

a. Cobra system (X-band) -

(1) CM study: Jam|signal ratios for C.W. jamming signals were measured and correlated with the theoretically expected values. Improvements in the spectral shape of the transmitted signal were made to increase the jam|signal ratio.

(2) Results of the flight tests of the air-target Cobra system were compiled as a TM to be published.

b. Coral (S-band) -

An improved power supply was utilized in a complete breadboard fuze system. Using coaxial delay lines, the system performed as expected.

PLANNED OBJECTIVES FOR NEXT PERIOD:

a. The theoretical optimum shape for the transmitted spectrum will be determined, based on jamming and reliability studies.

b. The Coral system will be rebuilt optimizing the parameters and tested on a free space target simulator.

BIBLIOGRAPHY:

S. Levine and J. W. Keller, Jr., "A High-Sensitivity, Wide-Range 'and' Gate (U)" DOFL M-51.1-56-4.

G.E. Advanced Electronic Center 7th Interim Progress Report - Contract no. DAI 308.

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 (Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

H. W. Straub
x 7660

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Dash-Dot

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: June 1954

ESTIMATED COMPLETION DATE:

- continuing
-
-**OBJECTIVE:**

To develop a tank defense consisting of a sensing and computing system for detecting the approach of antitank missiles and generating a firing pulse to detonate a line charge on the tank at the right instant to defeat the missile.

STATUS:

1. Background: A system using X-band radar doppler sensing has been in development by a contractor, the United Shoe Machinery Corporation, since Jun 54. Various problems of theory have been resolved. A laboratory model of the system has been designed and built. Laboratory and field tests of the model have been done. System evaluation, error study, and improvement are continuing with the object of developing a working model. At DOFL, a system using a multilayer infrared screen for sensing has been in development since Jan 56. Various IR sources and detectors have been investigated. Some problems of theory have been resolved and others are being studied. A laboratory model of the sensing system has been built and tested by simulated missile firings in the laboratory and in the large air-gun.

2. Results during Report Period: The contractor has built a target signal simulator to aid in circuitry testing. Antenna pattern studies and system error studies have continued.

Tests of the IR system at DOFL indicate fairly good location and velocity determination on missiles fired up to 1000 ft/sec. Various related studies have continued.

PLANNED OBJECTIVES FOR NEXT PERIOD:

Antenna pattern measurements will be continued by the contractor. Circuitry for a zero-doppler system will be designed, built and tested.

DOFL will made trajectory measurements on missiles up to several thousand ft/sec. S/N ratio will be determined as a function of system parameters. Related studies will be continued.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

H. W. Kohler

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7498

TITLE: Barometric Fuzing of Rockets and Guided Missiles

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret
(basic project)

DATE ITEM STARTED: July 1954

ESTIMATED COMPLETION DATE:

- End FY 1958
-
-**OBJECTIVE:**

To develop barometric fuzes for rockets and guided missiles in the Mach number range 0.5 to 5.0 and fuzing altitudes up to 40,000 ft; secondary interests include Mach numbers as high as 15 (Ltr OCO to AEC-SFOO dated 18 May 1954, file reference 004c 10420).

STATUS:

1. Background: A test vehicle (M5TV) which is to attain a maximum speed of Mach 5 has been designed; development of its rocket motor (XML7) has been contracted to Thiokol Chemical Corporation. Static tests of motor showed resonant burning at 110° - 160° F. Pressure probes and a low-volume baro switch (MC586) have been developed. Due to design modifications and motor difficulties, test program has been delayed approximately 6 months.

2. Results during Report Period: Progress. Static rocket motor firings were continued by Thiokol at Redstone Arsenal. Stable burning of the motor was obtained at temperatures up to 90° F. Dummy test vehicles were dropped from aircraft; aerodynamic stability was proved as well as telemetering operation.

PLANNED OBJECTIVES FOR NEXT PERIOD:

Launching from aircraft of rocket motor powered M5TV's; telemetry of pertinent test data. No work in DOFL is planned.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

H. W. Straub

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7660

TITLE: Ion Detection in Combustion Engine Exhaust

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: July 1955

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

To develop means for ionization detection in exhaust trails of combustion engines and its application to fuzing and/or guidance.

STATUS:

1. Background: Basic experiments have confirmed that a flame produces charged particles which will cause detectable changes in the current in an ionization chamber.

2. Results during Report Period: A high-Q (50,000) microwave cavity resonant in the X-band has been constructed. A long delivery time of Invar steel which was required, and a shortage of manpower in the shops, caused a delay of several weeks. To detect ions and electrons introduced into the cavity, it was decided to use a frequency comparison method capable of detecting a frequency difference between a test cavity and a standard cavity equal to $\frac{1}{Q}$ percent, where Q is that of the test cavity.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To continue tests on microwave cavity; continue gathering data concerning exhaust trails of combustion engines; to continue preparations for compensating effect of temperature variations on resonant frequency of cavity.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

A. L. Hedrich

x 7671

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Frequency Modulated, VHF/UHF Fuzing

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: July 1951

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

To investigate frequency modulated radio type fuzing systems operating at frequencies near 100 mcs.

STATUS:

1. Background: The use of a saturable ferrite cone in the tank of an oscillator to produce a frequency modulated signal at carrier frequencies up to 150 mcs has been investigated and found to be practicable. A fuze for use against ground targets and having a function height of about 1000 feet has been built and is to be tested in 500 lb bombs.

2. Results during Report Period: A phase sensitive detection system was analyzed and applied to the 1000 foot ground approach fuze to reduce the response corresponding to the secondary maxima in the function $J_0(\gamma)$. Three units were constructed and two of them were dropped in 500 lb bombs from an altitude of 8000 feet at the Blossom Point Proving Ground. The fuze oscillator was tracked from release and operated normally throughout the drop, but the smoke puffs indicating fuze function failed to appear.

PLANNED OBJECTIVES FOR NEXT PERIOD:

1. Analyze data available from first drop and prepare for additional drops of similar units.

2. Investigate new methods for frequency modulating oscillators at higher radio frequencies for fuze applications.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

C. Hardin
x 7672

TITLE: Short Pulse Radar

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret
(basic project)

DATE ITEM STARTED: January 1954

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

1. Fundamental investigation of high resolution ranging and detection systems which utilize pulse modulation radar techniques.
2. Utilization of these principles in fuze systems for guided missiles which require low altitude capability.
3. Application of SPR to related Ordnance tasks (MDI, FC, etc.)

STATUS:

1. Background: A miniature high resolution radar system, capable of transmitting X-band pulses of 20 millimicrosecond duration and 150 kc rep rate has been developed. (REF: TR-194, TM-56-1 - Symposium record University of Michigan 1956). This system has been utilized in a laboratory model fuze which possesses a range cut-off of 4 db/ft, and has a statistical cutoff region against aircraft of less than 2 ft. Laboratory, field, and flyover tests have been performed. Applications to altimeter and surveillance have been investigated.

2. Results during Report Period:

- a. Gating: I.F. amplifier gating studies were continued. An "off" gating system using only passive components has been developed for use with the surveillance radar.
- b. Surveillance Radar: A mobile surveillance radar system has been completed and operated on nearby highways.
- c. Reflectometer: The short pulse reflectometer work has been completed and a report prepared.
- d. The initial phase of the ARI amplifier contract has been completed. An amplifier has been designed without mutuals and with a reduction in size.

PLANNED OBJECTIVES FOR NEXT PERIOD:

1. Publication of a report on the short pulse reflectometer.
2. Completion of the study of pulse characteristics of ferrite cores.

BIBLIOGRAPHY:

- Monthly Report no. 1 - Contract DA-49-186-502-ORD-432
Monthly Report no. 2 - Contract DA-49-186-502-ORD-432

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

John Scales

PROGRESS REPORT FOR PERIOD: 1 July - 30 September 1956

x 7115

TITLE: Magnetic Devices

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: Secret
(basic project)

DATE ITEM STARTED: 1953

ESTIMATED COMPLETION DATE:

- continuing
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OBJECTIVE:

The purpose of this project is to develop the theory and carry out laboratory measurements necessary for the design of magnetic devices to operate below the microwave range. Examples of such devices are: magnetic amplifiers, shift registers, and memory circuits

STATUS:

1. Background: Present work is along two lines: gathering empirical data on the operation of magnetic amplifiers and switching circuits, and attempting to get improved theories for the operation of these non-linear devices.

2. Progress: Several transistor-magnetic core circuits have been built and their operation analyzed.

- a. a pulse counter using one core (counts to 10 or 50, etc.)
- b. a memory circuit (adds pulses and holds the sum)
- c. a d.c. to a.c. converter

Performance curves were run on a magnetic amplifier with diodes. The results correlated the theory.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To improve characteristics of the devices that are now working and to get a more accurate theory for explaining their operation.

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DIAMOND ORDNANCE FUZE LABORATORIES
 (Reports Control Symbol ORDTX-114)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X388
J. Witte

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Development and Evaluation of Klystrons for GM Fuzes

PRIORITY: D/A: 1-A

OOO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

1948

ESTIMATED COMPLETION DATE:

- Continuing
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OBJECTIVE:

To monitor klystron development contracts, to evaluate tubes produced, and to advise guided missile fuze engineers on the applications of the tubes.

STATUS:

1. Background: This project started in 1948. Under this project, Varian Associates developed the R-1A and R-1B klystrons. Development of the R-1A has been completed and the R-1B is now under production refinement. Work is to be started on a klystron of the R-1B type at a higher frequency.
2. Results during Report Period: Production drawings and tools were completed and the first R-1B tubes fabricated by production personnel. Yields were poor at first due to insufficient control of the brazing time of the cathode ceramic seal. Various changes in techniques and materials were made before adequate control was obtained. Eight tubes were received and found to be of uniformly good quality. It was found that the R-1B retains all its excellent performance characteristics when loaded by half-height waveguide. It was also found that the R-1B can be tuned ± 100 mc by the use of an external cavity between the tube and its load.
3. Recommendations: Work should continue as planned with special emphasis on investigation into means of increasing yields by better process control.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To improve production techniques used with R-1B and to start development of tube at higher frequency.

BIBLIOGRAPHY:

J. J. Witte, "Mechanical Tuning of an R-1B Klystron by an External Cavity,"
 DOFL TR #R52-56-5, 17 July 1956.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X388

J. Witte

PROGRESS REPORT FOR PERIOD: 1 July 1956 to 30 September 1956

TITLE: Development and Evaluation of Magnetrons and TR Tubes for GM Fuzes

PRIORITY: D/A:1-A

OCO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

1952

ESTIMATED COMPLETION DATE:

- Continuing

OBJECTIVE:

To monitor development contracts, to evaluate tubes produced, and to advise guided missile fuze engineers on the applications of the tubes.

STATUS:

1. Background: Several types of magnetrons and TRs are being evaluated for use in GM fuzes. Emphasis is on mechanical ruggedness and reliable snap-on operation after storage. Work on a medium power pulsed magnetron and a comparison TR is continuing with reduced effort. At present, primary effort is on the development and evaluation of a ruggedized 100-watt pulsed magnetron for a surface target fuze.
2. Results during Report Period: Twelve medium power magnetrons were received and found to meet all electrical and mechanical requirements.

Shock and vibration tests on several 100 watt pulsed magnetrons revealed intermittent operation of the heater and cathode. A change in cathode connector design was found to solve this problem. An investigation was started to determine the cause of spectrum spread during vibration at 800 to 900 cps.

3. Recommendations: The new cathode connector should be incorporated in all future tubes and the investigation to determine cause of spectrum spread during vibration should be continued.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To determine the cause of spectrum spread and produce sufficient tubes for tests in fuze units and to continue stability measurements after storage.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES
(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X388
H. W. A. Gerlach

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Development of a Rugged, Voltage-Tuneable Magnetron (V.T.M.)

PRIORITY: D/A: 1-A

OOO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

April 1956

ESTIMATED COMPLETION DATE:

- Continuing
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OBJECTIVE:

The object of this project is to develop a rugged, compact voltage-tuneable magnetron in the 2000-4000 mc band with 1-5 watts power output for use in the Coral fuzing system.

STATUS:

1. Background: Sample voltage-tuneable magnetrons have been procured from G.E. for study purposes. Special circuitry studies are also under way.
2. Results during Report Period: Several cavities for this V.T.M. were considered. One cavity is completed and ready for investigation. A second one is being constructed. An electromagnet for use with the V.T.M. has been designed and is under construction.
3. Recommendations: It is recommended that a contract be let to the manufacturer of the V.T.M. to develop a package including the V.T.M., the cavity and magnet.

PLANNED OBJECTIVES FOR NEXT PERIOD:

- (1) To continue study and evaluation of the present tubes.
- (2) To design a new anode structure for this V.T.M.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X388

W. E. Waters

PROGRESS REPORT FOR PERIOD: 1 July 1956 to 30 September 1956

TITLE: Feasibility Study of Wide-Band Oscillator at X-band, Using No Magnets

PRIORITY: D/A: 1-A

OCO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

July 1956

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To study and construct a wide-band, voltage-tuneable, microwave oscillator for GM uses; tubes are to require no magnets.

STATUS:

1. Background: The effort has included a survey of possible means of electrostatically focussing the beam and a survey of possible RF circuits which would be (a) highly efficient, (b) rugged, (c) light weight, (d) easy to manufacture.
2. Results during Report Period: Four promising ideas for generation and focussing of suitable electron beams were originated. Early experiments are very encouraging. Three electron-gun designs were finished, and parts were made.
3. Recommendations: More time should be devoted to the search for high-efficiency structures, as well as electrostatic focussing methods for high-perveance electron beams.

PLANNED OBJECTIVES FOR NEXT PERIOD:

Further study of electrostatic focussing methods will be undertaken. Study of suitable circuits will continue.

BIBLIOGRAPHY:

None.

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(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X388

B. J. Udelson

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Development of a Low-Noise Transverse-Field Traveling-Wave Tube

PRIORITY: D/A: 1-A

OOO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

February 1956

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To further develop the transverse-field traveling-wave tube employing electrostatic focusing (as first designed by Dr. R. Adler of the Zenith Corp.) with the following objectives: (1) optimize gain and minimize noise figure, (2) make tube mechanically rugged and minimize microphonics.

STATUS:

1. Background: The present work has been devoted towards the construction of a tube similar in construction to the Adler tube. Simultaneously, means of changing the design for obtaining ruggedized tubes is under investigation.
2. Results during Report Period: Two tubes similar to the Adler tube were constructed, but difficulties in assembly and processing caused a shorting of the bifilar helices. In addition, two other tubes have been constructed for studying improvements in gun design. A means of having the traveling-wave circuit constructed by printed circuit techniques (to replace the wires wound on a lava mandrel) was under study.
3. Recommendations:

PLANNED OBJECTIVES FOR NEXT PERIOD:

It is planned to construct an operating tube similar to that designed by Dr. Adler. Work on the improvement of gun design and on the use of printed-circuit techniques to form the traveling-wave circuit will continue.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA3-9101

D/A506-01-001

ENGINEER(S): X388

W. E. Waters

PROGRESS REPORT FOR PERIOD: 1 July 1956 to 30 September 1956

TITLE: Development of a Retarded-Field Oscillator (RFO) at 18 kmc.

PRIORITY: D/A: 1-A

OOO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

June 1956

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To develop an RFO at Ku band to achieve greater efficiency and less ion trapping than in a reflex klystron.

STATUS:

1. Background: This is a new project. The first effort is to develop a suitable electron gun.
2. Results during Report Period: The first experimental gun has been designed and built, but has not yet been tested.
3. Recommendations: To continue work toward a suitable gun design, and to consider the possibility of contracting part of the work to Ohio State University.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To study several gun anode grid combinations.

BIBLIOGRAPHY:

None

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S): X7074

J. W. Lathrop

PROGRESS REPORT FOR PERIOD: 1 July 1956 to 30 September 1956

TITLE: Semiconductor Device Research and Development

PRIORITY: D/A:1-A

OOO:

LOCAL:

SECURITY CLASS: SECRET

DATE ITEM STARTED:

July 1954

ESTIMATED COMPLETION DATE:

- Continuing

OBJECTIVE:

To develop a high-frequency transistor suitable for ordnance applications.

STATUS:

1. Background: A facility for the production of single-crystal germanium having varying electrical properties has been set up. Facilities for the production of diffused base transistors from this material are being constructed.
2. Results during Report Period: Equipment for the evaporation and alloying of the emitter and base contacts was completed. The first two diffused base transistors were produced which showed transistor action.
3. Recommendations:

PLANNED OBJECTIVES FOR NEXT PERIOD:

A greater quantity of transistors will be produced in order to study the control of the electrical parameters by process variations.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

P. J. Franklin

PROGRESS REPORT FOR PERIOD 1 July 1956 - 30 September 1956

Ext. 350

TITLE: Ceramic Component Development, on work order at NBS

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: (S)
(Basic Project)

DATE ITEM STARTED: July 1954

ESTIMATED COMPLETION DATE:

- Continuing
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OBJECTIVE:

(1) To control and reduce aging in ceramic capacitor bodies, (2) to develop a commercial method of fabricating $\text{Pb}(\text{Zr}_{0.55}, \text{Ti}_{0.45})\text{O}_3$ piezo-electric bodies, (3) to develop an analytical procedure for the analysis of barium titanate, (4) to develop a process for producing thin polarizable films of barium titanate ceramic on metal bases by electrophoretic deposition and subsequent firing of the titanate.

STATUS:

1. Background: (1) It was found that several undesirable variables would have to be eliminated in the investigation of the effect of minor constituents on spectroscopically pure BaTiO_3 .

(2) Exploration of possible sagger materials showed BaTiO_3 and (Ba-Sr) TiO_3 to be resistant to PbO and, if dense, to minimize the weight loss in specimens.

(continued on next page)

2. Results during Report period: (1) The characteristics of a low-frequency dielectric relaxation effect noted in pure ceramic BaTiO_3 with fired-on silver paste electrodes have been studied from 35 to 80° C. Preparation of dispersions for fractionalization of BaTiO_3 powders has been successfully accomplished. Work has started on growing single crystals of TiO_2 from aqueous solution.

(2) Chemical analysis of specimens of $\text{Pb}(\text{Zr}_{0.55}, \text{Ti}_{0.45})\text{O}_3$ has indicated a positive correlation between weight loss and PbO loss. However, the weight loss underestimates the PbO loss by a factor of two.

(continued on next page)

3. Recommendations: Continuation of all tasks.

PLANNED OBJECTIVES FOR NEXT PERIOD:

(1) The effect of electrode material on dielectric relaxation will be studied. Temperature and frequency ranges will be extended.

(2) Analyses will be run on more specimens to establish more thoroughly correlation of PbO loss with weight loss. Work will continue on preparing suitable crucibles. (continued on next page)

BIBLIOGRAPHY:

A. D. Franklin, Letter Rept. No. 7 on NBS Project 0900-11-4461, "Study of Ceramic Dielectrics", 19 Sept 1956.

R. Gilchrist, Rept. for Quarter Ending Sept 30, 1956, "Analysis of Titanates".

V. A. Lamb and H. I. Salmon, NBS Rept 4859, "Electrophoretic Deposition of Barium Titanate", 28 Sept 1956.

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15 Sept '56

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Ceramic Component Development on work order at NBS

1. Background: (continued)

(3) An analytical procedure was developed employing new and more easily controlled reactions; also, the need for operating in strongly acid solutions was largely avoided.

(4) Of the deposition techniques tried, the suspension media, diethylene glycol dimethyl ether with a sulfonated hydrocarbon as a stabilizing agent and large particle sizes, gave best results.

2. Results during Report Period: (continued)

(3) Synthetic mixtures of titanium and zirconium oxide were prepared from 1% TiO_2 -99% ZrO_2 to 99% TiO_2 -1% ZrO_2 . Separation with the developed analytical technique was sharp over the entire range.

(4) An investigation of the effect of firing temperatures and times, and the substrate metal employed, on the hardness of the deposit was begun.

PLANNED OBJECTIVES FOR NEXT PERIOD: (continued)

(3) Other impurities will be introduced into the synthetic samples to check the analytical scheme.

(4) The investigation of firing conditions will be continued.

DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):
E. M. Davies
ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Printed Circuitry

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: (S)

(basic project)

DATE ITEM STARTED: Year 1943

ESTIMATED COMPLETION DATE:

- Continuing
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OBJECTIVE:

To develop printed circuit techniques. Particular emphasis is placed on a study of printed resistor ink formulations, printed capacitors formed by a compression molding process, and etched circuits.

STATUS:

1. Background: Formulations for both printed resistors and printed capacitors have been developed and evaluated to determine their storage and operating characteristics under various environmental conditions, and the effect of various parameters of component fabrication on the value and performance of the unit.

2. Results during Report Period: The effect of varying the percent curing agent in the resistor ink formulation was determined for both electrical and physical characteristics of the resistor. Increasing the amount of curing agent increased the resistance values. The only adverse effect noted from the increase was a greater sensitivity to humidity for the units with a high percentage of curing agent. An investigation of various carbons for use in resistor ink formulations was begun.

Breakdown voltage tests on some of the printed capacitors indicate that a rating of 150v will probably be feasible.

3. Recommendations: Continuation of study.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To evaluate carbons, curing agents, and milling times for resistor inks and to test printed capacitors according to Military Specification MIL-C-11015A.

BIBLIOGRAPHY:

E. M. Davies, DOFL Rept. No. R53-56-21, "Preparation of Small Parts for Vacuum Tubes", 17 Aug. 1956.

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

Laurel Maxwell

Ext. 7591

PROGRESS REPORT FOR PERIOD 1 July 1956 - 30 Sept 1956

TITLE: Ceramic Component Development

PRIORITY: D/A:1A

OCO:41

LOCAL:

SECURITY CLASS: (S)

(Basic Project)

DATE ITEM STARTED: July 1952

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To evaluate and improve ceramic materials and techniques for application in fabrication of fuze components.

STATUS:

1. Background: Methods of sealing ceramic windows to stainless steel waveguides have been under investigation with efforts concentrated on a sealing technique which will maintain a good seal at high temperature. The barium titanate-bismuth stannate binary system has been investigated with the hope of developing a capacitor body with improved temperature characteristics.

2. Results during Report Period: A method of attaching ceramic windows to stainless steel waveguides was tried using titanium-cored silver solder and an induction heater in place of a previously used furnace. The method is promising but too many leaky seals have been noted to consider the technique perfected as yet.

The results of an investigation of the dielectric properties of the barium titanate-bismuth stannate system in the region of 1.0 to 5.0 mole percent bismuth stannate indicate that compounds from this system do not possess superior properties to commercial capacitor bodies now available.

A program was initiated for producing high capacitance-to-volume-ratio capacitors by stacking thin ceramic discs. A stacking technique was developed but difficulties in fabricating and handling ultra-thin wafers must still be overcome.

3. Recommendations: Continuation of work.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To perfect the technique of sealing ceramic windows to stainless steel waveguides using titanium-cored silver solder and the induction heater. Techniques for the incremental polarization of six-inch piezoelectric rods will also be investigated.

BIBLIOGRAPHY:

L.E. Shoot, DOFL Rept. No. R53-56-18, "Literature Survey of Ceramic-to-Metal Seals", 6 August 1956.

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA3-9101

D/A 506-01-001

ENGINEER(S):

J.E. Sensi

Ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Equipment Development

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: (S)
(Basic project)

DATE ITEM STARTED: Year 1943

ESTIMATED COMPLETION DATE:

- Continuing

OBJECTIVE: To develop special machinery for the fabrication and proper evaluation of materials, components, processes, and techniques.

STATUS:

1. Background: Machines developed in past work include a potting machine for casting resins, devices for the evaluation of adhesives, and equipment for applying conductive patterns to dielectrics.

2. Results during Report Period: A bath for preparing etched circuits has been completed. Work has progressed on (1) a machine for extruding and orienting thin dielectric films, (2) automatic machine for printing up to twelve resistors, each with different inks, simultaneously, (3) flushing device for cleaning ink reservoirs, (4) device for loading reservoirs, (5) conveyor oven, (6) conveyor furnace, and (7) spinning table.

3. Recommendations: Continuation of work.

PLANNED OBJECTIVES FOR NEXT PERIOD: To progress on all above-mentioned machines. However, the degree of progress will be limited by the fact that one engineer will be devoting a major portion of his time to another project of higher priority.

BIBLIOGRAPHY: Timothy J. Kilduff and John E. Sensi, DOFL Rept. No. R53-56-13, "Techniques for Evaluation of Adhesive Bonds Under Elevated Pressures and/or Temperatures", 14 June 1956.

John E. Sensi, DOFL Rept. No. R53-56-20, "Device for Orienting Related Patterns on Bilateral Surfaces", 10 August 1956.

John E. Sensi and Philip J. Franklin, "Machines and Methods for Applying Casting Resins" Electronic Equipment, Vol 4, No. 7, (July 1956).

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA3-9101

D/A 506-01-001

ENGINEER(S):

Martin Belfield
Ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Coherer-Type Switch

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: (S)

(Basic project)

DATE ITEM STARTED: January 1956

ESTIMATED COMPLETION DATE:

- Continuing
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OBJECTIVE: To develop a rugged solid-state switching device which will change from a high impedance to a very low impedance upon application of a critical voltage, and to develop procedures for fabricating reproducible units.

STATUS:

1. Background: Work was begun in January 1956 on an electrostatic switch patterned after the old-time coherer. This device utilizes an electric field to align aluminum and other particles contained between metal electrodes. When the electric field reaches sufficient strength to align the conductive particles, the resistance drops from several megohms to less than a hundred ohms.

2. Results during Report Period: A switch was developed which consisted of a line, ruled in the copper of a copper-clad laminate, filled with beeswax in which had been embedded finely divided aluminum. Tests indicated an initial resistance of 10^{10} ohms which dropped to about one ohm when the voltage reached a critical value, usually between two and ten volts. The component is at present not ready for production because the problems of spontaneous firing by external radiation, and wide spread in firing voltages, have not been solved.

3. Recommendations: Continuation of study.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To produce pilot lots of switches, test them, and make design changes as indicated. The advantages of various materials for electrodes and fills will also be investigated.

ET LIOGRAPHY

No reports were issued this quarter.

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

L. H. Bullis

ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Vacuum Deposition of Thin Metal and Dielectric Films

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: (S)

(basic project)

DATE ITEM STARTED: October 1954

ESTIMATED COMPLETION DATE:

- Continuing

OBJECTIVE: To develop miniature, stable, electrical components by the use of vacuum evaporation techniques.

STATUS:

1. Background: Thin-film components can be expected to be smaller than, as well as electrically and thermally superior to, some currently available resistors, capacitors and rectifiers. Success in preparing thin-film components depends, in large measure, on the development of methods for producing films of (a) some metals not yet successfully evaporated, (b) certain combinations of metals, and (c) dielectrics.

(continued on next page)

2. Results during Report Period: Attempts to produce silicon dioxide (quartz) films for capacitor dielectrics by vapor deposition using various techniques recommended in the literature were not promising, either because of reduction of the dioxide to the monoxide or because of the length of time required to obtain films of the thickness desired. The best films contained an estimated 85% of the dioxide and 15% of the monoxide. A

(continued on next page)

3. Recommendations: Continuation of work.

PLANNED OBJECTIVES FOR NEXT PERIOD: To improve methods for deposition of quartz films and to attempt to more accurately determine the silicon dioxide-monoxide ratio in such films. A study of the relative merits of a-c vs d-c glow discharge cleaning will also be undertaken.

BIBLIOGRAPHY:

No reports were published this quarter.

Vacuum Deposition of Thin Metal and Dielectric Films (continued)

1. Background: (continued)

Some preliminary vacuum deposited capacitors have been prepared with dielectric films of silicon monoxide and various thin-film electrodes. Thin-nichrome-film resistors have also been made.

2. Results during Report Period: (continued)

study of a-c glow discharge cleanup in the vacuum chamber showed that use of the baseplate as one terminal produced inferior cleaning to that obtained using a two-terminal system.

A number of rectifiers were successfully prepared by the successive evaporation of bismuth, selenium, and cadmium onto the type of copper-clad laminate board which is used for etched circuits.

DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A506-01-001

ENGINEER(S):
T.J. Kilduff
Ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept 1956

TITLE: Development of Adhesives

PRIORITY: D/A:1A

OCO: 41

LOCAL:

SECURITY CLASS: (S)
(Basic project)

DATE ITEM STARTED: July 1953

ESTIMATED COMPLETION DATE:
- Continuing
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OBJECTIVE:

To develop high-temperature-resistant adhesives, as well as other adhesives with special characteristics, required by the fuze program.

STATUS:

1. Background: Good high-temperature properties of adhesives must, in some cases, be coupled with low-temperature flexibility, low electrical loss, or low water-vapor permeability. Rubber-phenolic and epoxy-phenolic adhesive systems have been investigated, primarily for guided-missile-antenna application. Special apparatus has been designed and constructed to permit the evaluation of adhesives under conditions of transient heating.

2. Results during Report Period: A conductive adhesive was formulated from an epoxy resin and silver flake. This adhesive is expected to serve as a cold setting solder where conventional solders do not adhere satisfactorily or where normal soldering temperatures cannot be tolerated. Relationships have been determined between electrical conductivity and silver-to-resin ratio and mixing time. Bond strength seems to be essentially independent of silver content or mixing time. The viscosity of the adhesive has been reduced by the use of a reactive diluent with the epoxy resin.

3. Recommendations: Conclude activity on conductive adhesives, and reinstate work on high-temperature adhesives.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To complete the study of conductive silver-epoxy adhesives. Emphasis will then be placed on epoxy-phenolic formulations, and on the bondability of special materials, such as sodium-treated polytetrafluoroethylene and various resin-glass cloth laminates.

BIBLIOGRAPHY:

T. J. Kilduff and J. E. Sensi, DOFL Rept. No. R53-56-13, "Techniques for Evaluation of Adhesive Bonds Under Elevated Pressures and/or Temperatures", 14 June 1956.

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DIAMOND ORDNANCE FUZE LABORATORIES

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

M. Maienthal
ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Dielectric materials for capacitor impregnants

PRIORITY: D/A: 1 A

OCO: 41

LOCAL:

SECURITY CLASS: (S)
(basic project)

DATE ITEM STARTED: Feb. 1954

ESTIMATED COMPLETION DATE:

See under "Background," Part

a) Termination -12-30-56

b) Continuation

OBJECTIVE:

To prepare, purify, and evaluate certain organic materials as impregnants for paper capacitors in order to reduce the size and increase the temperature and frequency ranges of operation of paper capacitors.

STATUS:

1. Background: Certain solids which are able to orient in an electrical field exhibit high dielectric constants and low dissipation factors. Two classes of such materials have been investigated: (a) a sterol mixture called ischolesterol, which has a dielectric constant of 12, and (b) derivatives of hexachlorocyclopentadiene (HCCP) which possess symmetrical structures and exhibit stability at very high temperatures.

2. Results during Report Period: (a) Impregnation of paper capacitors was carried out with a mixture of a chlorinated polyphenyl and ischolesterol and resulted in a three-fold increase in capacitance. Since the calculated eight-fold increase was not attained it was concluded that the impregnation was not complete. (b) A ketone of cage-like structure was prepared from HCCP. Its dielectric constant was ordinary but its losses were quite low. The ketone was converted to the corresponding alcohol, acetate, and tosylate.

3. Recommendations: Termination of work on the sterols is planned at the end of the next quarter (see above). Continuation of work on the cage-like structures is recommended.

PLANNED OBJECTIVES FOR NEXT PERIOD: (a) Isocholesterol will be mixed with other materials in an attempt to reduce its crystallinity and allow it to be impregnated into paper. (b) Additional paper capacitors will be impregnated and evaluated. (c) The HCCP derivatives will be converted to the cyanide which is expected to be polar and to possess a high dielectric constant. The cyanide will be employed in impregnation studies.

BIBLIOGRAPHY:

R. W. Tucker and M. Maienthal, DOFL Rpt. No. R53-56-22, "Sterols as Capacitor Impregnants," 24 August 1956.

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PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

E. R. Nelson

ext. 7591

PROGRESS REPORT FOR PERIOD 1 July - 30 Sept. 1956

TITLE: Development of Casting Resins for Electronic Encapsulation

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: (S)
(basic project)

DATE ITEM STARTED: Year 1943

ESTIMATED COMPLETION DATE:

- Continuing

OBJECTIVE: To develop flexible, as well as rigid, casting resins with special electrical, physical, and handling properties for use in electronic encapsulations for fuzes.

STATUS:

1. Background: Styrene-type casting resins with low dielectric constants and losses have been developed previously. Polybutadiene was thermally crosslinked to form a rigid plastic with superior electrical and thermal properties. Polybutadiene was also epoxidized to yield a flexible casting resin.

In an attempt to prepare casting resins with greater flexibility, superior electrical properties, and low curing temperatures, work was begun on: (1) the synthesis of epoxy-polyether resins, and (2) a somewhat parallel investigation, the preparation of a series of monoglycidyl ethers for use as reactive plasticizers.

2. Results during Report Period: Various attempts were made to prepare diglycidyl ethers of ethylene glycols. Among these were: (1) reaction of the glycol with bases and subsequent treatment with epichlorohydrin; and (2) reaction of a diallyl ether of a glycol with hypochlorous acid to form the chlorohydrin.

Certain monoglycidyl ethers (butyl, octyl, and dodecyl) were successfully prepared as plasticizers but attempts to prepare longer chain monoglycidyl ethers failed. The butyl glycidyl ether was used as a reactive diluent with a commercial epoxy resin.

3. Recommendations: Continuation of work.

PLANNED OBJECTIVES FOR NEXT PERIOD: Preparation of epoxy-polyethers will be attempted by the direct epoxidation of diallyl ethers of ethylene glycols. The reaction of glycols with bases will be resumed, in this case with bases soluble in tetrahydrofuran, in the hope of obtaining both diglycidyl ethers as well as longer chain monoglycidyl ethers.

BIBLIOGRAPHY:

- C. G. Fitzgerald et al, "Epoxy-polybutadiene Resins", Electronic Equipment 4, No. 7, 64 (July 1956).
A. A. Benderly et al, "Protective Potting of Glass Vacuum Tubes and Ceramic Capacitors", Electronic Equipment 4, No. 7, 36, (July 1956), and S.P.E. Journal 12, No. 8, (August 1956).

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

A. I. Talkin

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7263

TITLE: Wideband Amplifier Design and Development

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: July 1955

ESTIMATED COMPLETION DATE:

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OBJECTIVE:

This project covers research on wideband amplifiers for use in fuzing systems.

STATUS:

1. Background: The need for wideband amplifiers for special applications has been in evidence. The design techniques using distributed amplification for a 50 megacycle amplifier in a DOFL short pulse radar development pointed the way for amplifiers of wider passband. The next step has been to design an amplifier of at least 200 megacycles bandwidth, 40 db minimum gain and sufficient voltage for one inch deflection of a 5 X P CR tube at 12 KW accelerating potential.

2. Results during Report Period: The development of the latest amplifier with 250 megacycle bandwidth and 43 db gain has been completed with all objectives obtained. The rise time of the completed amplifying system including a wideband balun and phase correcting network in addition to the amplifiers is 2.5 millimicroseconds.

PLANNED OBJECTIVES FOR NEXT PERIOD:

Several reports describing this development will be written in conclusion of this item.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

S. H. Gordon

x 7454

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Transistor Circuit Research

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: Secret
(basic project)

DATE ITEM STARTED: 1952

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

The purpose of this work is to gain proficiency in transistor circuit theory and experimentation. This includes investigation of the limitations of available transistors and development of circuits to overcome these limitations.

STATUS:

1. Background: The program has included the study of basic transistor theory, actual device characteristics, and a large number of experimental circuits utilizing transistors. Many of the circuits have been incorporated into new fuze systems now being studied by other groups.

2. Results during Report Period: Digital counting circuits have been successfully operated up to 5 mc. The SEAC machine computation of transistor video amplifier performance has been expanded to include one form of compensation which improves the passband characteristic. Continuing aid has been given the Guided Missile Fuze Lab personnel working on an experimental transistorized fuze.

PLANNED OBJECTIVES FOR NEXT PERIOD:

The various studies will continue. Improved high frequency counters will be investigated. Increased aid will be given to other groups using transistors.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

J. C. Cacheris

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7026

TITLE: Investigation of Ferrite Applications

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: Secret
(basic project)

DATE ITEM STARTED: December 1951

ESTIMATED COMPLETION DATE:

- continuing research

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OBJECTIVE:

Utilization of observed phenomena for the invention of basic ferrite devices; and application of these devices to radio and guided missile fuze systems.

STATUS:

1. Background: A X-band ferrite single-sideband modulator has been designed for use as a doppler simulator. The behavior of a magnetically tuned cavity has been investigated theoretically and experimentally. Magnetic tuning of X-band klystrons has been achieved for applications requiring very wideband frequency modulation. A novel and compact duplexer-detector has been devised for microwave systems using a common antenna for transmission and reception. Magnetostrictive detection of modulated X-band signal has been observed. An investigation has been initiated to map the electric field configurations in rectangular waveguide so that broadband devices can be achieved. A theoretical and experimental study is being made of the properties of VHF ferrite antennas.

2. Results during Report Period: Chemical bonding, silver plating and high saturation cores were used to improve the performance of the magnetically tuned klystron.

Experiments were made to determine the nature of dimensional resonances in ferrite-loaded rectangular waveguide so that they can be eliminated from practical devices.

The cutoff frequencies for the TE_{10} and TE_{20} modes in a rectangular waveguide containing a dielectric have been theoretically determined.

The acoustic match between the ferrite and barium titanate rods of the microwave detector has been theoretically analyzed. (continued on back)

PLANNED OBJECTIVES FOR NEXT PERIOD:

The frequency and power characteristics of the magnetically-tuned klystron will be investigated as functions of reflector voltage and modulation signal. The magnetic path will be redesigned for operation at large modulation frequencies.

The detection theory of the ferrite microwave detector will be expanded to determine the optimum position of the rod and to determine the effect of d.c. magnetization. (continued on back)

BIBLIOGRAPHY:

J. C. Cacheris and H. A. Dropkin, "Compact Microwave Single-Sideband Modulator Using Ferrites" IRE Transactions on Microwave Theory and Techniques, Vol MTT-4 No.3 July 1956.

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Investigation of Ferrite Applications

2. Results during Report Period - Con't

Although preliminary measurements indicated the feasibility of making antenna measurements in the near field to within 20%, continued indoor measurements made with air core loops have been inconsistent. Roof measurements have been consistent to within 34%.

A synchronous rotary phase shifter and electronic circuits were designed for the microwave phase meter.

PLANNED OBJECTIVES FOR NEXT PERIOD - Con't

The electric fields inside a waveguide containing a ferrite slab will be analyzed in order to determine the position of the slab for maximum difference in the electric fields for the two directions of propagation.

The accuracy of the phase meter will be measured after a balancing section has been made to produce a zero effective line length.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

H. W. Straub

x 7660

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Optical Fuzing Research

PRIORITY: D/A: 1A

OOO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: September 1955

ESTIMATED COMPLETION DATE:

- continuing

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OBJECTIVE:

To invent and investigate ranging and detecting systems which use ultra-violet, visible or infrared radiation as the carrier of information.

STATUS:

1. Background: Efforts of this group have been suspended since December 1955 due to the fact that the more urgent IR phase of project 'Dash-Dot' was started. Contract work on ultraviolet phosphors for flying-spot C.R. tubes is being carried out at Philco Corporation, Philadelphia, Pa. Contract work on high-frequency modulation of light has just begun at the Physics Dept., Kansas State College, Manhattan, Kansas. Work on development of ultraviolet polarizers is being done at the National Bureau of Standards, Section 5.11.

2. Results during Report Period: Work at Philco has resulted in a phosphor that has its peak intensity at 2900Å. No results of high-frequency modulation of light have yet been reported. No ultraviolet polarizers have yet been produced.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To continue technical supervision of present contract.

BIBLIOGRAPHY:

Tenth Interim Research Report on Fuzing Systems, Contract no. DAI-49-186-501-ORD(P) - 206, Philco no. H-2012 dated 15 June 1956, for period 1 Feb to 30 Apr 56.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-9101

D/A 506-01-001

ENGINEER(S):

J. Cacheris

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7026

TITLE: Microwave Properties of Ferrites

PRIORITY: D/A: 1A

OCO: 41

LOCAL:

SECURITY CLASS: Secret

(basic project)

DATE ITEM STARTED: December 1951

ESTIMATED COMPLETION DATE:

- continuing research

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OBJECTIVE:

Basic and applied research investigation of the microwave properties of ferrites; fundamental measurement studies; and development of special measuring equipment in order to specify materials suitable for improving the performance of ferrite devices.

STATUS:

1. Background: The birefringent properties of ferrites are being investigated at X-band frequencies as functions of the applied magnetic field. The parallel permeability components of the magnetic tensor has been determined at X-band frequencies for a few ferrites in the region below saturation.

2. Results during Report Period: Preliminary measurements were made of the frequency shift of a ferrite loaded cavity with temperature and magnetic field as parameters.

The birefringent measurements indicate that for a given magnetic field, ferrite tubes which make contact with the circular waveguide have larger differential phase shifts than tubes not touching the wall. Also, for the same differential phase shift at the center of the frequency band, the phase shift of the former geometry is less frequency sensitive.

PLANNED OBJECTIVES FOR NEXT PERIOD:

Measurement of the real and imaginary components of the parallel and perpendicular permeabilities by means of a ferrite loaded TE₁₀₂ cavity.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-11A)

PROJECT NO.: TB-0001

D/A 5B 99-01-004

ENGINEER(S): X7074

A. L. Ward

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Effect of Pressure on Metal-to-Semiconductor Contacts

PRIORITY: D/A:

OOO:

LOCAL:

SECURITY CLASS: Unclassif.

DATE ITEM STARTED:

1 July 1956

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To study the effect of pressure on electrical characteristics of a metal-to-semiconductor contact as a function of the surface condition, the dimension of the contacts, and the bulk properties of the materials.

STATUS:

1. Background: Originated 1 July 1956 as the result of preliminary work which indicated that practical devices utilizing this principle may be feasible.
2. Results during Report Period: A literature search has revealed background material that has greatly speeded our theoretical investigation. In order to test the developing theory, laboratory measurements have been made and some partial agreement has been noted. A special sample holder, with reduced lead capacity, has been constructed for use in measuring the effect of pressure upon contact capacity.
3. Recommendations: Continue as planned.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To extend measurements to other surface conditions, contact dimensions, and semiconductor resistivities and to continue theoretical study.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA3-4105

D/A 506-03-002

ENGINEER(S): X7074

M. J. Reddan

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Basic Mechanisms of the Townsend Discharge

PRIORITY: D/A: 1-C

OOO: 288

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: 1953

ESTIMATED COMPLETION DATE:

- Continuing

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OBJECTIVE:

To study pre-breakdown conditions existing in the Townsend discharge.

STATUS:

1. Background: Initial work was performed as part of the trigger tube program. Breakdown data was obtained which agreed acceptably with a curve calculated from theory. With the termination of the trigger tube program, this aspect of the program is being continued as a separate project.
2. Results during Report Period: Static breakdown curves were taken for argon gas using plane parallel electrodes. Results did not entirely agree with expectations. Reasons for this were sought through a study of the experimental conditions. One result of this was the design and construction of an optical system which makes possible greatly improved accuracy in manometer readings. Almost all the techniques necessary for obtaining SEAC solutions to the DOFL adaptation of a recent theory* of the Townsend region have been worked out.
3. Recommendations: Continue as planned.

PLANNED OBJECTIVES FOR NEXT PERIOD:

1. To obtain further static breakdown data on argon gas using nickel electrodes.
2. To install a means for monitoring gas purity by taking frequent test samples.

BIBLIOGRAPHY:

R. W. Crowe, J. K. Bragg, and V. C. Thomas "Space Charge Formation and the Townsend Mechanism of Spark Breakdown in Gases," *Physical Review*, Vol. 96, No. 1, pp 10-14, 1954.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-114)

PROJECT NO.: TA3-4105

D/A 506-03-002

ENGINEER(S): X7074

M. J. Reddan

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

TITLE: Radioactive Cold-Cathode Amplifier Tube

PRIORITY: D/A: 1-C

OOO: 288

LOCAL:

SECURITY CLASS:

DATE ITEM STARTED: 1953

ESTIMATED COMPLETION DATE: Secret
- Continuing (basic project)

OBJECTIVE:

Develop an improved cold-cathode gas-filled amplifier tube for a fuze application where a low power requirement is desirable.

STATUS:

1. Background: Preliminary work in 1953 indicated the feasibility of designing a radioactive, cold-cathode amplifier tube. The earlier work is now being extended to explore further the possibilities existing in such tubes.
2. Results during Report Period: A preliminary investigation was carried out on models of a radioactive amplifier tube constructed with three different geometries. Analysis of the data indicated (1) a restricted region of ionization was necessary to maintain high input impedance, (2) higher plate currents resulted from a geometry which favored the production of maximum utilizable ionization, and (3) certain geometries favored higher efficiency of the electric field in separating ions and electrons, and a consequent higher amplification factor.
3. Recommendations: Continue as planned.

PLANNED OBJECTIVES FOR NEXT PERIOD:

To obtain full data on the most recent tube constructed as well as determine the effects of minor variations in its geometry and its response in actual circuits.

BIBLIOGRAPHY:

None.

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DIAMOND ORDNANCE FUZE LABORATORIES

(Reports Control Symbol ORDTX-113)

PROJECT NO.: TA 3-8503

D/A 506-01-012D

ENGINEER(S):

D. R. Pardue

PROGRESS REPORT FOR PERIOD: 1 July to 30 September 1956

x 7671

TITLE: Ultrasonic Flowmeter (Navy)

PRIORITY: D/A: 1A

OO: 41

LOCAL:

SECURITY CLASS: Secret

DATE ITEM STARTED: April 1955

ESTIMATED COMPLETION DATE:

- January 1957

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OBJECTIVE:

To develop a sonic liquid flowmeter.

STATUS:

1. Background: This project was initiated at the request of the Navy, where the need existed for a device to measure the flow of the primary coolant in an atomic reactor. It operates on the same principle as the ultrasonic flowmeter originated in this laboratory while under the National Bureau of Standards. At the beginning of this reporting period the electronics for a system was in the breadboard stage but it employed a means of temperature compensation that was only useful for variations in sound velocity up to about 15%.

2. Results during Report Period: The velocity of sound in water at temperatures up to 540°F was measured. The velocity decreased much more than the first estimate by the Navy indicated. The system for temperature compensation in use now is not sufficient to take care of the variation in sound velocity indicated by these measurements.

PLANNED OBJECTIVES FOR NEXT PERIOD:

1. A new method of temperature compensation.
2. Finalization of the electronics design.
3. Construction of a unit to be tested in an operating or test loop.

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